Introducing Time-Based Metering at Los Angeles Air Route Traffic Control Center

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1. Introduction

The Traffic Management Advisor (TMA) is a key tool in FAA's Free Flight program [1]. Its software enables en route controllers and traffic management specialists to plan efficient arrival sequences while aircraft are still several hundred miles from their destinations. Initially developed by NASA Ames Research Center [2], with subsequent development by Computer Sciences Corporation and Northrop Grumman under contract to FAA, the Free Flight Program Office (FFPO) has deployed TMA to seven air route traffic control centers with four more planned for future deployment. The system is currently in daily use at Denver, Fort Worth, Minneapolis, Atlanta, Los Angeles, Miami, and Oakland Centers.

One important option available in TMA is time-based metering (TBM) – a method for managing periods of high arrival demand by scheduling the times aircraft cross designated points on the terminal radar approach control (TRACON) boundary. It has been shown [3] to allow for more efficient use of terminal area capacity during busier periods. The commonly used miles in trail (MIT) method of arrival flow control that places a limitation on how closely one aircraft follows another is a much more subjective form of metering aircraft, and typically offers inconsistent results. Although a proven concept, TBM has not been widely used, primarily due to limited accuracy of earlier metering software such as Arrival Sequencing Program (ASP) [4], and because it requires a change in operational thinking. TMA provides, among other features, highly sophisticated trajectory modeling to facilitate TBM.

The Los Angeles Air Route Traffic Control Center (ZLA) has historically managed the flow of air traffic into Los Angeles International Airport (LAX) using a combination of MIT spacing and dynamic internal departure control. ZLA, in conjunction with Southern California TRACON (SCT), is currently testing the use of TBM operationally in an effort to maximize available runway capacity at LAX during periods of peak traffic.

Under a transition plan developed by the FFPO and an on-site ZLA cadre headed by a local NATCA representative and a traffic manager, a group of controllers and traffic managers has been in the lead in introducing TBM at ZLA. An assessment of human factors affecting the acceptance of TBM was carried out by Human Solutions, Inc. To date the transition has successfully passed several critical milestones and has demonstrated significant benefits at ZLA and SCT for LAX arrivals. The process is still underway and several issues remain before a final decision to complete the transition is made.

This paper describes the initial stages of this complex transition as it was carried out at ZLA. It presents key transition issues, including the use of simulations to familiarize controllers with TBM techniques, phased introduction of TBM on the control room floor, coordination of the transition with adjoining centers and TRACON's, and site-specific tuning of TMA to achieve best TBM performance in ZLA airspace.

2. TMA Overview

TMA is an automated planning tool that allows center traffic management specialists and controllers to develop more efficient aircraft arrival sequences in the extended terminal airspace around major airports such as LAX. TMA helps ensure that demand in excess of airport or TRACON capacity is safely and efficiently absorbed throughout the airspace. TMA essentially distributes delays back from low-altitude TRACON sectors into higher-altitude center sectors, where delays can be more efficiently absorbed.

TMA considers current and future traffic flows that enter center airspace from adjacent centers or depart from feeder airports within the center and are destined for the arrival airport. It makes accurate calculations and rapid updates of aircraft scheduled times of arrival (STA) at fixes and runway thresholds based on radar track or flight plan data. Using TMA, the traffic management coordinators (TMC) creates a plan to deliver safely separated aircraft to the TRACON at a rate that keeps pressure on the arrival airport without exceeding its capacity. The plan consists of aircraft sequences and STA's at designated points in the airspace, including meter fixes (published points that lie on the center–TRACON boundary), final approach fixes, and runway thresholds.

TMA assists the TMC in making strategic decisions about arrival operations during periods of heavy traffic (i.e., rushes) to regulate the flow of aircraft into the arrival airport. Prior to a rush, TMA can help TMCs decide when to start TBM by providing an accurate picture of future arrivals up to an hour in advance.

During TBM, TMA generates a time-sequenced aircraft meter list that is displayed on the radar positions of center controllers in arrival metering sectors. The meter list displays aircraft ID, scheduled meter fix and outer metering arc crossing times, and delay for each aircraft. Using speed changes and vectors, controllers implement a TBM plan by causing aircraft to cross meter fixes and arcs at the TMA-calculated times.

TMA provides information via several primary graphical user interfaces. The Timeline Graphic User Interface (TGUI) displays the estimated time of arrival (ETA) and STA of arrival aircraft in a time-ordered sequence. It also produces load graphs that display the number of aircraft crossing different reference points in a given period of time. The Planview Graphical User Interface (PGUI) presents a map-oriented view of arriving aircraft [5].

3. Transition Process

ZLA is using a phased approach to transition to TBM. Two groups of arrival sectors (ZLA Areas A and C) were selected for initial transition. ZLA designated a cadre of controllers from each area as the first to be trained and to field test TBM. Following successful completion of field tests and a decision to proceed, other controllers in Areas A and C will be trained. ZLA Areas B and E will also be trained and begin using TBM. The initial cadre forms an experienced core to assist training the additional controllers.

A significant aspect of the TBM transition process was training of the controller cadre using simulations of ZLA airspace. Two training simulations at the FAA William J. Hughes Technical Center (WJHTC) were conducted to introduce the TBM concept and demonstrate how it works in conjunction with TMA. Controllers from SCT also participated in the second simulation. Controllers took their simulation experience back to the center and TRACON to conduct a seven-week live field test of TBM. The goals of the field test at ZLA and SCT were to put TBM into practice in managing LAX arrival traffic in Areas A and C and at the TRACON feeder sectors, to evaluate its effectiveness and to identify and address any issues with TBM or the use of TMA. The rest of this section details the key events and activities in the transition process.

<u>ZLA Cadre Simulation – September 2000</u>. The ZLA extended cadre received their initial introduction to TBM in the fall of 2000. A group of controllers from ZLA Areas A and C participated in a two-week training event held in the Display System Replacement (DSR) high-fidelity lab at the WJHTC. ZLA TMC's, TMA subject matter experts (SMEs), and Free Flight and WJHTC personnel also participated in the simulation. The controllers received briefings on TMA and its potential benefits, and participated in simulations both with and without TMA. In addition to the training benefits, controllers provided valuable inputs on TMA, TBM and lessons learned from this simulation.

ZLA and SCT Simulation – March 2002. A two-week follow-on training simulation was held in March 2002 to provide additional hands-on experience with TBM. Predominately, the same cadre of ZLA controllers from the initial simulation, along with additional controllers from ZLA and SCT, participated in the training at the WJHTC DSR and Automated Radar Terminal System (ARTS) high-fidelity simulation facilities. The primary objectives of the ZLA cadre during the simulation included developing initial skills in TBM, developing and practicing techniques for absorbing metering delays, and understanding the functionality of the TMA DSR meter list. The cadre participated in numerous simulation runs to try various TBM techniques, develop their skills, and determine which techniques worked well under various conditions. SCT controllers joined the simulation in the second week to gain experience controlling aircraft at TRACON feeder sectors during TBM.

Dynamic Simulation (DYSIM) training at ZLA. After completion of training at the WJHTC, the ZLA cadre returned to the center and began training in their DYSIM laboratory. The scenarios run at the WJHTC were converted for use in the ZLA DYSIM lab. Primary DYSIM training goals included continuing TBM training for participants in the WJHTC simulation, plus training additional cadre members prior to taking TMA to the control room floor.

ZLA Field Test. Following DYSIM training, a seven-week live field test of TBM was held at ZLA and SCT. The goals of the field test included evaluating the use of TBM in managing LAX arrivals via ZLA Areas A and C and SCT sectors East Feeder and Zuma. TBM runs were performed nominally five days per week, as weather conditions permitted, and were timed to occur during rushes. Following each day's runs, de-brief teleconferences with SCT were held to discuss the runs, how the feed looked, and TBM and TMA issues.

A follow-on test period is scheduled for the fall of 2002. This will confirm whether TMA software fixes for issues discovered in the field test have been properly completed. Resolution of these issues is key to successful operational transition to TBM at ZLA.

Decision on Full-Scale TBM Use. Once TMA fixes have been addressed, a decision will be made whether to continue TBM at ZLA and expand its use to other areas. The plan is to train remaining Area A and C controllers, followed by training for Area B and E.

4. Lessons Learned

Simulations and DYSIM training. The ZLA controllers felt the familiarization simulations were important steps in preparing the ZLA extended cadre for their transition to TBM. Through the simulations and DYSIM training, the controllers became familiar with using TMA, including the functionality of the meter list and use of the delay countdown. They gained experience with techniques to absorb various levels of delay, and learned how much delay could be absorbed in each sector. The simulations also provided the cadre with an understanding of the types of background information that should be provided to controllers as they are trained in TMA. The simulations also suggested what could be done differently in future TBM simulations.

Another important step in the ZLA transition was the participation of SCT in the second WJHTC simulation. During the training, ZLA controllers had the opportunity to rotate positions across runs and to work SCT feeder positions to see how their input affected SCT. During the second week, SCT controllers worked the feeder positions and also observed ZLA operations. All participants felt the interaction between the two facilities and the experience of seeing how TBM relates to the whole picture was invaluable.

ZLA Field Test. The ZLA field test provided controllers an opportunity to use TBM in a live environment for the first time. They continued to build on experience gained in the simulations and in local DYSIM training. Controllers found the delay techniques learned thus far worked effectively in the live trials. Due to airspace limitations, the controllers found that most of the delays needed to be absorbed in the high sectors. This resulted in the controllers having to use speeds, vectors and sometimes holding to a much greater extent in high sectors than when TBM was not in use. Taking delays in high sectors resulted in aircraft being lower and slower as they were handed off to SCT feeder positions.

Controllers continued to gain experience with the TMA meter list and use of the delay countdown. It became apparent during the field test that controllers frequently referred to the TMA TGUI's and PGUI's located in Areas A and C. The TGUI allowed them to see exactly where aircraft were located on the timeline, as well as to see future traffic coming to their sector. Both PGUI and TGUI provided a useful overall picture of arrival traffic throughout the center. This assisted controllers in recognizing when, for example, TMA was delaying traffic in a lightly loaded west sector due to heavy traffic in the east.

The field test gave ZLA and SCT TMC's the opportunity to try various TMA settings to determine which would provide the best feed into LAX. Changes to the configuration of TMA, including location of freeze horizons and meter fixes, various stream class settings, and assigning priority to one meter fix, were made to determine which configuration worked best in ZLA's airspace. MIT restrictions from adjacent centers also had to be taken into account and changed as daily conditions warranted.

During the field test, a number of issues related to TMA were discovered and are in the process of being resolved. One of the primary issues at ZLA was the way TMA had been designed to schedule internal departures. Other issues that are being resolved involve TMA runway allocation, problems with some aircraft not displaying on the controllers' meter lists, and problems with certain aircraft freezing late. It quickly became apparent that addressing these types of site-specific issues is a key element for a successful transition.

5. Benefits

Efficiency in spacing on finals was improved during TBM runs. With TBM, aircraft were typically delivered at a rate of 6 miles in trail. This compared to a typical rate of 15 miles in trial using miles in trail. The improved flow coming into SCT also resulted in faster speeds on finals. During the rushes with TBM, TMC's at ZLA and SCT felt more aircraft were landed per hour at LAX than would have been using pre-TMA miles in trail; typically 3 to 4 additional aircraft per hour were landed during instrument meteorological conditions using TBM. This experience is consistent with other centers, such as Fort Worth Center which indicates the use of TMA has allowed them to increase the arrival rate to DFW airport by 5 percent.

SCT also saw benefits when TBM was in use. TMA helped create smoother traffic flows into the TRACON, so aircraft were delivered to SCT feeder positions at lower altitudes and slower speeds. This resulted in more manageable flows and a significant decrease in no-notice holding. The improved flows also resulted in more predictable delays, and less verbal coordination was required between ZLA and SCT controllers. Aircraft in parallel streams were properly staggered when TBM was in use. This was especially noticeable in the east (Area C), where two flows blend into one for handoff to SCT East Feeder.

6. Conclusion

TMA is a key component of FAA's Free Flight program. It provides significant benefits, including more efficient use of busy airport resources. ZLA traffic managers have used TMA since its installation there, but implementing TBM is key to getting the greatest benefit from the tool. Successful adoption of TBM requires training and dedication of the controller workforce to put the techniques into practice, and it has required the continued support of SCT during the transition period. ZLA is the first center to transition to TBM from miles in trail, so its ability to make the transition successfully to date has important implications for other centers that may make the transition in the future. Lessons learned at ZLA will prove invaluable to these sites.

References

1. See http://ffp1.faa.gov/ for further information.
2. Additional details are available at www.ctas.arc.nasa.gov/.
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